Towards collaborative human and robotic rescue workers

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Abstract— **This paper discusses some of the main remaining bottlenecks towards the successful introduction of robotic search and rescue (SAR) tools, collaborating with human rescue workers. It also sketches some of the recent advances which are being made to in the context of the European ICARUS project to get rid of these bottlenecks.**

I. INTRODUCTION

In the event of a large crisis, a primordial task of the fire and rescue services is the search for human survivors on the incident site. This is a complex and dangerous task, which often leads to loss of lives. The introduction of unmanned SAR devices can offer a valuable tool to speed up the search and rescue process and to save human lives. Recent technological advances in the field of crisis intervention robots [3], mostly in the field of automated control [2] and automated victim search [1] have shown that the technology is maturing. However, recent crises like the Tohoku earthquake in Japan have learned that there exists a large discrepancy between robotic technology which is developed in science labs and the use of such technology on the terrain for search and rescue operations. While this can be partly explained by a lack of technological maturity, a major part of the explanation for this lies in the fact that the human rescue workers need to understand and accept the novel robotic technologies. Here, we discuss some of the bottlenecks impeding acceptance.

II. DEPENDABILITY & RELIABILITY

Human SAR workers need to be able to depend on their robotic tools; sometimes they even put their lives in the hands of these robotic systems. This poses huge requirements on the reliability of the SAR robots. Often, robots which are developed in science labs feature a lack of reliability when confronted with real-life situations. Environmental aspects like rain, dust, wind, heat or cold, absence of light or heavy sunlight are all factors which need to be considered. The robot must also be reliable from a mechanical point of view.

As the human SAR workers are so dependable on these robot, they are anxious to accept an important degree of robot autonomy, while autonomy is required in many cases (e.g. when communication is lost). This illustrates the need for human-friendly user interfaces, supporting supervision of shared autonomy. In the ICARUS project, an intelligent shared autonomy framework is proposed where the human operator controls all higher-level robot operations, without needing to worry about low-level control aspects.

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III. DEPLOYABILITY

In order for any robotic system to be used in real crisis operations, it is required that the robots can be deployed fast to the crisis area. In practice, this means that it must be possible to have the robots ready to be embarked at the national airport, within a few hours after getting notice. Air transportability is a key factor, which imposes huge requirements on the weight and size of the robotic system. In order for the human SAR teams to be able to handle these robotic systems easily, they must be enclosed in easily liftable boxes, containing all required tools and batteries.

IV. USER ACCEPTANCE ISSUES & SPACE MANAGEMENT ISSUES

Currently, it is the case that when human and robot SAR teams work on the same incident site, they do this in segregated space: the robots are given a zone where they can operate and no human SAR workers enter in this zone for safety reasons (see e.g. [3]). Obviously, this space segregation limits the effectiveness of the SAR operations. In the future, it is the objective of the ICARUS project to work towards more intelligent space management approaches and really let human and robotic rescue workers interact in the same environment. However, this requires the delimitation of certain space management rules.

V. ECONOMICS & LEGAL ISSUES

The development of robotic technologies has no sense if they cannot be deployed because of legal issues. Specifically aerial systems are plagued by this problem, due to restrictive airspace access. Also economic issues have to be considered. SAR teams have limited budgets and cannot buy excessively expensive robots. Also the operational cost is important: e.g. robotic technologies requiring too much on heavy internet traffic must be avoided, because internet access in crisis zones (via satellite) is extremely expensive.

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